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UNITED STATES DEPARTMENT OF AGRICULTURE

BULLETIN No. 992

Contribution from the Bureau of Entomology
L. O. HOWARD, Chief

Washington, D. C. November 4, 1921

WALNUT HUSK-MAGGOT.[1]

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INTRODUCTION.

The larva of the walnut husk-maggot has long been known to persons who in autumn have engaged in hulling the nuts of our native black walnut (*Juglans nigra*). Soon after the nuts drop, a large percentage of them are frequently found with the hulls blackened and slimy within and containing multitudes of whitish maggots which move actively through the soft pulp. Such infested nuts are disagreeable to handle, and in hulling the husk sticks to the inner shell, leaving it dirty and unattractive in appearance (Pl. IV, *d*). Inasmuch as the fruit of the black walnut was not important commercially in the past this insect did not attract especial attention, and very few persons, even of those who were familiar with the maggots in the walnuts, ever saw the parent fly. If seen, it was probably seldom regarded as being in any way connected with the disgusting

[1] *Rhagoletis suavis* Loew; order Diptera, family Trypetidae. A closely allied species, *Rhagoletis juglandis* Cresson, has been recorded as attacking the nuts of *Juglans rupestris* and *J. regia* in Arizona and Texas. Several members of the same genus have attracted considerable attention in North America on account of the destructiveness of the larvæ to various kinds of fruit. *R. pomonella* Walsh, known commonly as the apple maggot or railroad worm, is an important pest of apples in the northern part of the United States and Canada. Two species, *R. cingulata* Loew and *R. fausta* O. S., attack cherries over practically the same region, while *R. ribicola* Doane frequently injures currants and gooseberries in the Northwestern States.

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condition of the nuts. It was not until an interest developed in certain places in the East in growing the Persian or English walnut (*Juglans regia*) commercially that a demand arose for information regarding this pest. When the Persian walnut trees planted in the East began to fruit, these maggots attacked the nuts and practically ruined very promising crops in several localities. The injury to Persian walnuts and the fact that the eastern black walnut, one of the favorite food plants of the species, is becoming of increasing importance from the standpoint of nut production, have led to the investigation described herein. The project is not yet completed, but the outstanding features of the life history and habits of the insect are now known. Further studies of the species, particularly along the lines of control, are under way.

BRIEF DESCRIPTION OF INSECT AND INJURY.

The adult of the walnut husk-maggot is a two-winged fly about the size of the common house fly. The flies appear on the walnut trees at the time the nuts are approaching maturity and lay clusters of white eggs in punctures made in the husk with their sharp ovipositor (Pl. III, *e*) or in breaks which they may find in the husk of the nuts (Pl. II, *b*, *c*, *d*). Apparently no eggs are deposited in the nuts after they drop. The eggs soon hatch and the resultant maggots rapidly convert the green tissue of the husk into black pulp. After attaining full growth the maggots enter the ground and pupate, there being only one generation of the flies annually.

SYNONYMY.

The following data covering the synonymy of the species were furnished by Mr. B. A. Porter, of the Bureau of Entomology:

Trypeta suavis Loew, 1862, *in* Monogr. Dipt. N. Amer., pt. 1, p. 75.
Acidia suavis Loew, 1873, *in* Monogr. Dipt. N. Amer. pt. 3, p. 235.
Rhagoletis suavis (Loew), 1899, *in* Coquillett, Jour. N. Y. Ent. Soc., v. 7, p. 260.

DISTRIBUTION.

This fly probably occurs pretty generally over the natural ranges of the black walnut and the butternut (*Juglans cinerea*). In 1862 Osten-Sacken[2] gave its distribution as the "Middle States." In 1902 Babb[3] reared the fly from black walnut at Amherst, Mass. Washburn,[4] in 1905, listed the species among the flies of Minnesota;

[2] LOEW, H. MONOGRAPHS OF THE DIPTERA OF NORTH AMERICA (ed. by R. Osten-Sacken), pt. 1, p. 75. Washington, D. C. 1862.

[3] BABB, G. F. NOTE ON RHAGOLETIS SUAVIS LW., WITH A DESCRIPTION OF THE LARVA AND PUPARIUM. *In* Ent. News, v. 13, no. 8, p. 242. 1902.

[4] WASHBURN, F. L. DIPTERA OF MINNESOTA. Minn. Agr. Exp. Sta. Bul. 93, p. 118. 1905.

and Banks,[5] in 1912, reared flies from butternuts at Plummers Island, Md. There are specimens in the United States National Museum from West Willow and Allegheny, Pa., and Dr. J. M. Aldrich, of the Museum, has in his personal collection specimens from Blue Ridge Summit, Pa., and La Fayette, Ind. During the present investigation the writer has collected or otherwise obtained specimens from the following localities: Boston, Mass.; Wallingford, Conn.; Lockport, N. Y.; West Willow and Washington Heights, Pa.; Columbus, Ohio; New Windsor, Md.; Washington, D. C.; and French Creek and other localities in West Virginia.

FOOD PLANTS.

The walnut husk-maggot has been known to attack commonly the husks of the black walnut (*Juglans nigra*) and the butternut (*J. cinerea*). The writer has reared adults from the husks of the Persian walnut (*J. regia*) and Japanese walnut (*J. sieboldiana*). Of the foregoing hosts the black walnut and Persian walnut are preferred to the others, probably on account of the thicker husks.

DESCRIPTION OF LIFE STAGES.

THE EGG.

The egg (Pl. II, *b*, *c*, *d*) is white, banana-shaped, distinctly curved, 0.9 to 1 mm. in length by 0.2 mm. in width, one end tapering gradually to a rounded point, the other end tapering more abruptly and ending in a minute but distinct spur or pedicle. The eggs are placed in masses compressed closely together (Pl. II, *b*, *c*, *d*) in oviposition punctures extending 2 mm., more or less, beneath the skin of the nuts. The female will oviposit freely in any fresh puncture which she may find in the skin made otherwise than with her ovipositor. Small punctures made experimentally in the husk with a sharp point usually were found promptly by the females and filled with eggs. In some cases such punctures would be packed with eggs and the flies would continue to oviposit on the surface until a small mound of eggs covered the opening in the skin (Pl. II, *d*). One artificial puncture in a black walnut was found to contain 186 eggs and several punctures made with the ovipositor were found to hold upwards of 60 eggs each. The eggs apparently hatch in from 7 to 10 days.

Oviposition takes place only in the green part of the husk, but after the maggots hatch and begin to feed the point of attack soon shows as a black spot on the surface (Pl. IV, *a*). This spot increases rapidly in size as the burrows of the maggots penetrate the tissues

[5] BANKS, NATHAN. THE STRUCTURE OF CERTAIN DIPTEROUS LARVÆ WITH PARTICULAR REFERENCE TO THOSE IN HUMAN FOODS. U. S. Dept. Agr., Bur. Ent., Tech. Ser. Bul. 22, p. 32. 1912.

beneath. Persian walnuts on the trees will often turn black from this cause during a period of only a few days. Quite often the first external evidence of the feeding of the larvæ within a nut will be a slight seepage of dark juice from the oviposition wound, which will flow down and stain the skin of the nut (Pl. IV, *b*).

THE LARVA.

The larva, or maggot (Pl. II, *e*, *f*; Pl. IV, *c*), is white or creamy white, and is not stained by the dye-like, semiliquid matter in which it feeds. The dark-colored contents of the alimentary canal, however, give to the immature maggots a brownish appearance. When full grown they average 10 mm. in length by 2 mm. in width. The maggots are active and move about rapidly, using in locomotion their two anal hooks. They often remain in the walnut husk until severe freezing weather occurs, but take advantage of warm periods in the late autumn to leave the nuts and enter the ground a short distance for pupation.

THE PUPA.

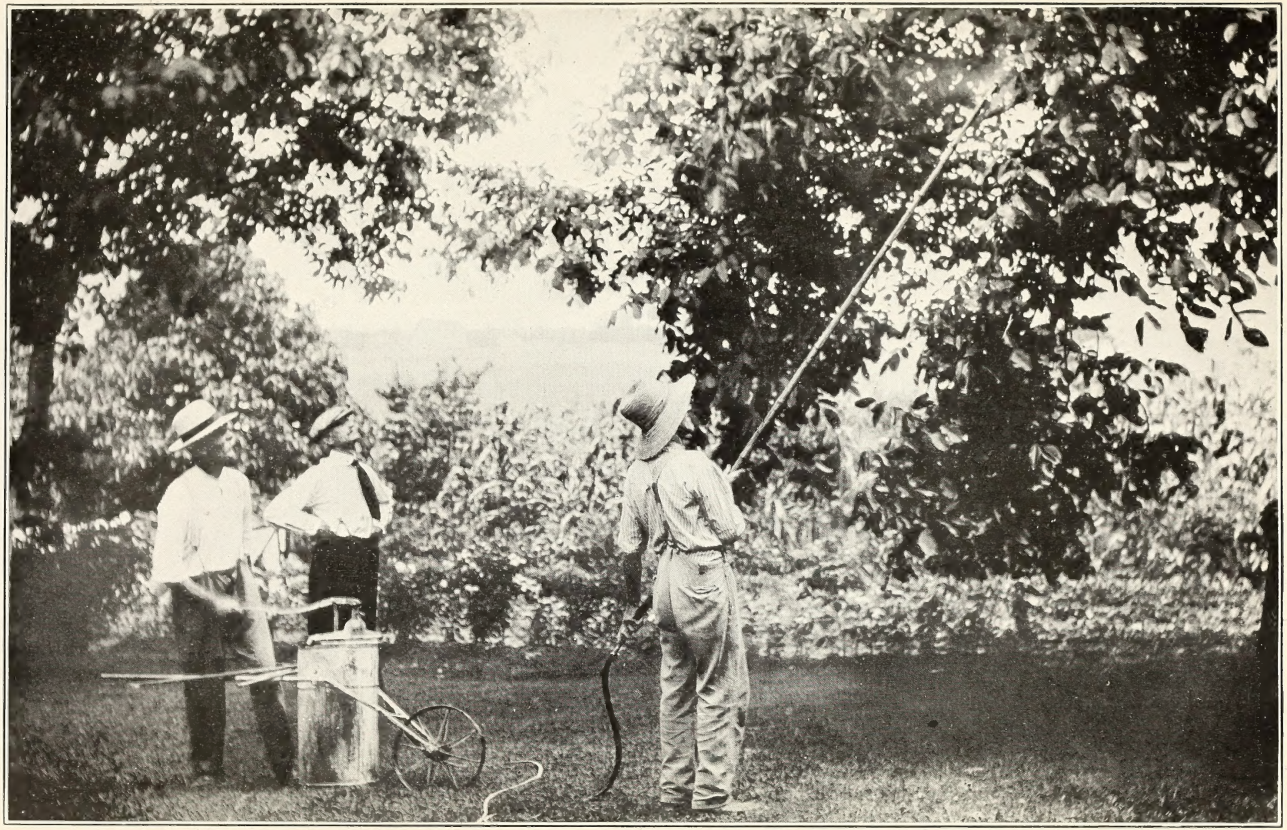
The pupa (Pl. II, *g*, *h*) is formed by the shrinkage of the larva and is pale yellow, cylindrical, tapers slightly from the middle toward the ends, and is 5 mm. in length by 2.5 mm. in width. There are 11 plainly visible segments, the intersegmental grooves being shallow but distinct. Each end bears a pair of small, brownish tubercles and there is a rough, brown spot near one end where the larval head was retracted. In size, shape, and color the pupa resembles a grain of wheat (Pl. II, *h*). The pupæ are formed in the ground, anywhere from half an inch to several inches beneath the surface, and the winter is passed in this stage. Most of the flies issue the following summer, but a few pupæ hold over the second winter and the adults appear therefrom during the succeeding summer.

THE ADULT.

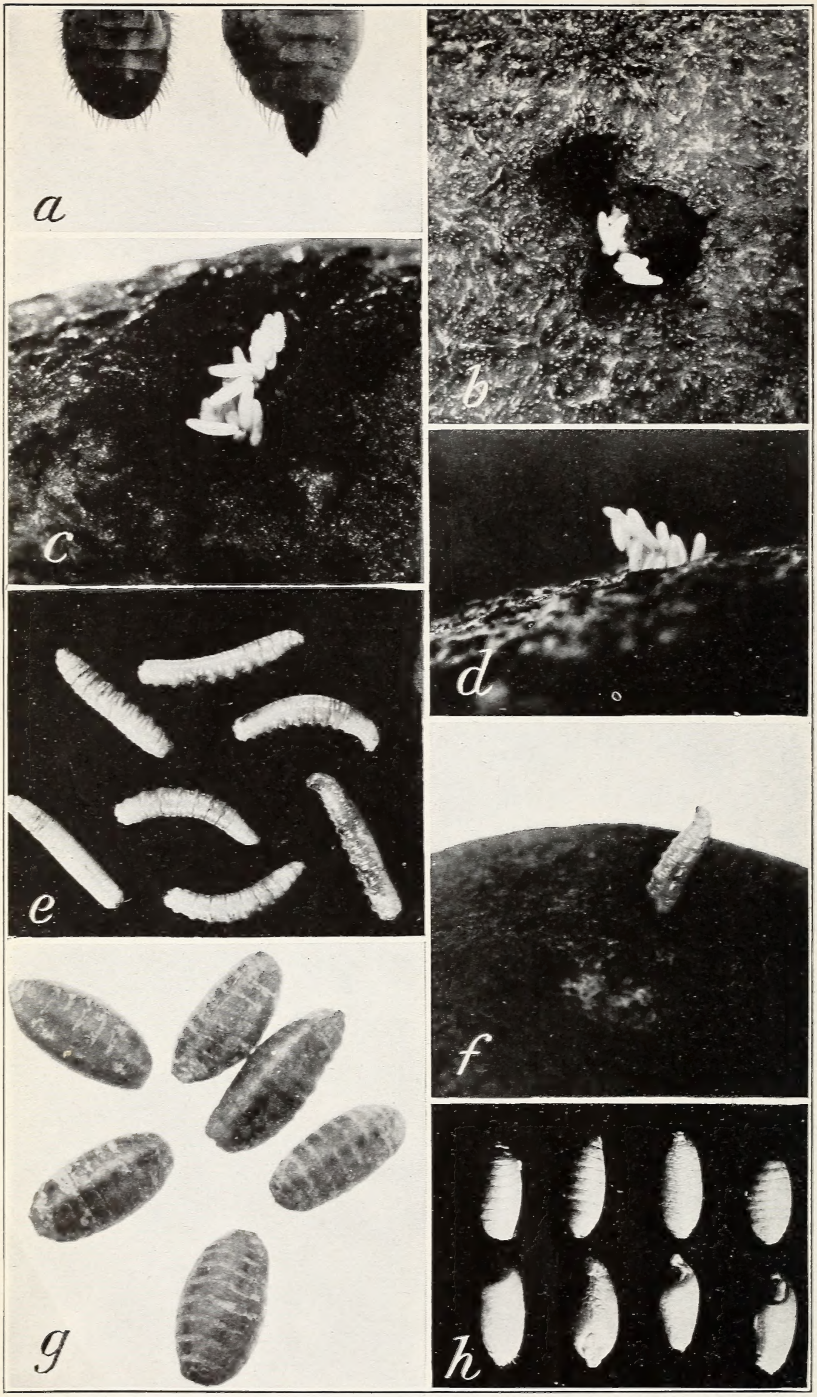
The adults of this insect vary considerably in size but average about 7 mm. in length. With the exception of the eyes, heavy wing markings, anterior margins of the abdominal segments, and bristle-like hairs, all of which are dark brown, the color is pale yellow. There is a lighter longitudinal line on each side of the thorax and the dorsal surface of the thorax is densely clothed with very short, yellowish hairs interspersed sparsely with long, stiff, dark-brown bristles. The head, sides, upper surface of the abdomen, and legs are covered more or less heavily with brown hairs. (Pl. III.)

ACTIVITIES OF THE FLIES.

The flies begin to issue from the ground at least as early as the middle of July in the latitude of West Virginia. In 1920 at French

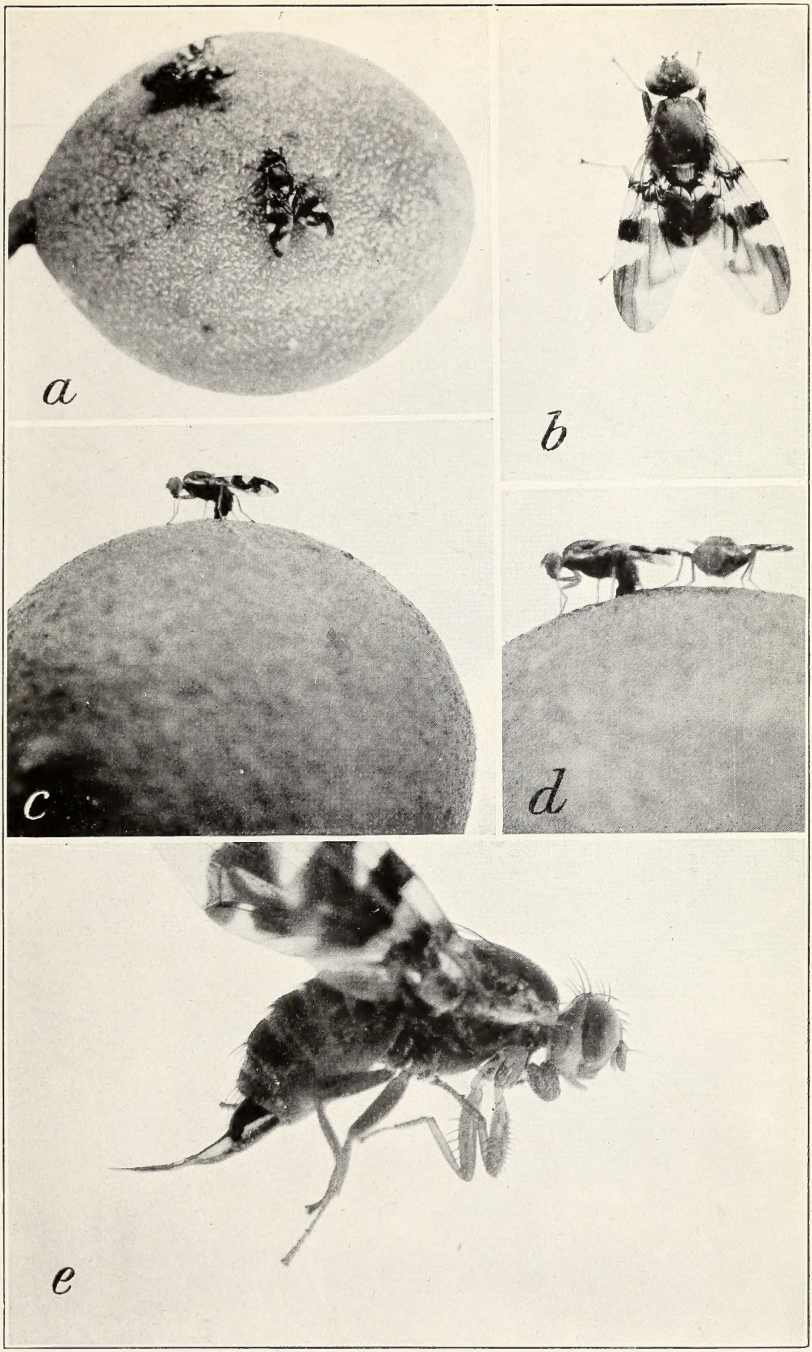


SPRAYING WITH LEAD ARSENATE TO CONTROL THE WALNUT HUSK-MAGGOT IN THE PERSIAN WALNUT GROVES OF J. G. RUSH, WEST WILLOW, PA.



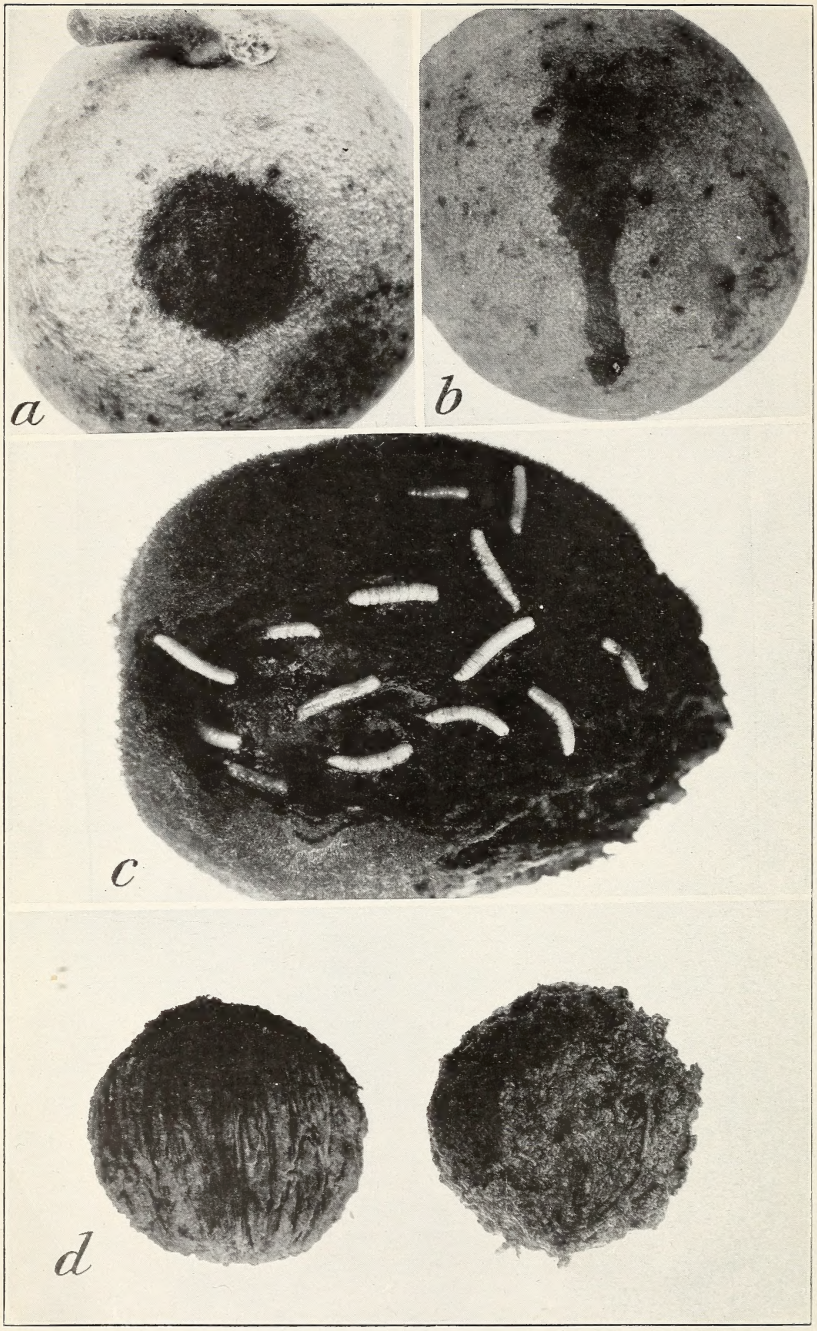
THE WALNUT HUSK-MAGGOT.

a, Genitalia of male and female husk-maggots, male on left; *b* and *c*, egg clusters in black walnuts exposed by cutting away the skin; *d*, egg cluster partly on the surface of black walnut; *e*, larvæ; *f*, larva escaping from a black walnut; *g*, pupæ; *h*, resemblance of pupæ, above, and grains of wheat, below. All enlarged.



THE WALNUT HUSK-MAGGOT.

a, Flies of husk-maggot on black walnut; *b*, fly of husk-maggot much enlarged; *c*, female in the act of depositing eggs in a black walnut; *d*, female laying eggs and guarded by a male; *e*, female with ovipositor extended. All enlarged.



THE WALNUT HUSK-MAGGOT.

a, Black walnut showing discolored spot on skin made by husk-maggots mining within; *b*, black walnut stained by juice flowing from oviposition scar; *c*, husk-maggots in Persian walnut; *d*, black walnuts with husk removed to show difference in hulling between sound and infested nuts; nut on the left sound, on the right infested. All about natural size.

Creek, W. Va., the first flies appeared in rearing jars on July 16, and on August 5 the first specimens were recognized definitely on the trees. Flies, apparently of this species, were seen on trees in both West Virginia and Pennsylvania several weeks earlier, but no specimens were captured and identification was not definite. Flies in rearing jars issued from July 16 to September 8, emergence covering a period of 55 days. Table I shows the time of emergence of 40 individuals in rearing jars.

TABLE I.—*Emergence of flies of walnut husk-maggot in rearing jars at French Creek, W. Va., in 1920.*

Date	Number of flies.	Date.	Number of flies.	Date.	Number of flies.	Date.	Number of flies.
July 16	1	July 31	1	Aug. 15	3	Aug. 29	0
17	0	Aug. 1	1	16	0	30	0
18	0	2	0	17	2	31	1
19	2	3	0	18	2	Sept. 1	0
20	0	4	1	19	3	2	0
21	1	5	0	20	0	3	0
22	0	6	1	21	0	4	1
23	1	7	1	22	0	5	0
24	0	8	1	23	1	6	0
25	0	9	1	24	1	7	0
26	1	10	0	25	4	8	1
27	0	11	0	26	4	9	0
28	0	12	2	27	1		
29	0	13	1	28	0	Total	40
30	0	14	0				

Apparently flies are present on the trees several weeks before oviposition begins. At first they occupy the foliage chiefly, making short flights from leaf to leaf and resting quietly for long periods. During the preoviposition period, as well as later, they may be seen lapping at the leaves as though extracting food from deposits on the surface. As the time for the beginning of oviposition approaches the flies become more active, and both males and females show a tendency to gather about the nuts. The males habitually select certain nuts on which an individual will take his stand and often remain for hours at a time awaiting the coming of the female, combating, meantime, other males that approach. When a male alights on a nut already tenanted by another male the original occupant attacks it and usually the two rear up on their hind legs, facing each other, and engage in a brief but animated bout, belaboring each other with their forelegs. Usually the original occupant is the victor and the would-be interloper flies away.

A prick made in a walnut with a pin or other sharp point was sure to be found by a male, who, recognizing it evidently as a suitable place for the females to come to oviposit, would immediately begin standing guard over it. In one instance the writer pricked a dozen walnuts on the lower branches of a tree with the point of a small nail. Thereafter for several days a male was on guard at each of the

punctured nuts and females were observed frequently to visit these nuts, where copulation and oviposition took place. In approaching these nuts the females usually came by easy stages, flying and crawling near the nut before alighting upon it. When the male would observe a female approaching he would become much excited, moving back and forth, whirling around, and raising and lowering the wings in rapid succession, but remaining near the puncture made with the nail point. On the arrival of the female upon the nut the male would usually back away from the nail puncture a short distance and there remain stationary, with wings elevated above the back, watching the female intently. When the female would find the puncture and start to insert the tip of her abdomen into the opening for the purpose of depositing eggs, the male would spring upon her and copulation would take place. There would then follow alternating periods of oviposition and copulation, the male sometimes continuing mounted while oviposition was in progress, and sometimes dismounting but remaining near by. (Pl. III, *d*.) Frequently there would be four or five periods of each before the female would fly away. After this procedure the male was likely to continue on guard at the same place, for the nail pricks were visited frequently by ovipositing females.

The flies were observed to be much more abundant on the lower than on the higher branches of trees, and there was a great difference in the numbers of flies on individual trees of the same species. On a group of heavy-laden Persian walnut trees of the variety known as Hall, at West Willow, Pa., it was estimated that one fly was present for every two nuts on the trees. The variation in the numbers of flies on individual trees was followed by a corresponding abundance or scarcity of maggots in the nuts of each.

Flies were observed to feed upon the juice that flowed from oviposition scars and upon the naturally more or less gummy surface of the nuts. In feeding they would eject from the mouth a particle of clear liquid onto the surface and after working it over with the purselike, external mouthparts would swallow it again.

NATURE OF INJURY.

In native black walnuts the eggs of the husk-maggot fly are usually deposited so late in the season that the resultant maggots do not prevent the nuts from maturing and dropping normally. Thus, while apparently all the eggs are laid in nuts on the trees, the development of the maggots and the blackening of the husks which results from their feeding take place chiefly in fallen nuts. In Persian walnuts, however, eggs appear to be laid earlier in the development of the nuts. Bearing trees were observed in Maryland and Pennsylvania, a short time before the crop had ripened, on which

a large percentage of the husks of the nuts were blackened throughout and the surface covered with a gummy exudation from the maggot injury within. Some of the infested Persian walnuts drop prematurely and others hang to the branches until after the sound nuts have fallen. In nuts that are attacked before maturing the development is arrested and the kernel becomes unfit for use. The injury is thus threefold, in that it impairs the quality of the kernel, causes the husk to stick to the shell in the hulling process, and blackens and soils the shell, making the nuts unattractive for market.

NATURAL ENEMIES.

Only one parasite of the husk-maggot has been discovered. This is a hymenopterous species, *Aphaereta auripes* Prov., reared from the puparia by Babb ([6]) at Amherst, Mass. The writer, on September 8, 1920, found a small leaf-bug, determined by W. L. McAtee as a species of Lopidea, with its beak inserted through the skin of a black walnut sucking out the contents of a batch of fresh-laid husk-maggot eggs. An examination of the eggs showed that a number of them had been punctured and emptied by the bug.

METHODS OF CONTROL.

Experiments in controling the husk maggot with lead-arsenate sprays were conducted in 1920 in the Persian walnut groves of Mr. N. H. Baile, at New Windsor, Md., and of Mr. J. G. Rush, at West Willow, Pa. Only a single application of the spray was made in each case. The grove of Mr. Baile consists of about a dozen seedling trees of various sizes, some of them about 30 years of age. At the time of the spraying all were bearing heavy crops of nuts. This grove was sprayed by means of a power sprayer on August 10, with 3 pounds of lead-arsenate paste to 50 gallons of water. The grove of Mr. Rush consists of 18 trees of named varieties, all of bearing age. The trees were producing heavily at the time the spray was applied. The spraying was done on August 9, using $1\frac{1}{2}$ pounds of lead-arsenate powder to 50 gallons of water. Two trees of the variety known as Rush, three of Hall, and two of Mayette were sprayed with the lead-arsenate solution to which enough molasses had been added to give the liquid a slightly sweetish taste. For treating the Rush grove a small hand sprayer mounted on a wheelbarrow was used (Pl. I). The trees of both groves had borne the previous season, but the crops had been injured seriously by the attacks of the maggots.

At the time the groves were sprayed the adults of the maggots were appearing on the trees and a close examination of the nuts in the Rush grove disclosed one batch of freshly laid eggs. After the spraying the Baile grove was not revisited until the nuts were almost

[6] BABB, G. F. OP CIT.

ripe. The Rush grove, however, was kept under close observation by Mr. Rush and the writer. The flies became very numerous on the trees of this grove for a period of a few days after the spray was applied and then decreased in numbers.

Examination and counts of the nuts of the sprayed trees in the Baile grove just before the crop was gathered showed that 4 per cent of the nuts had been attacked by the maggots, whereas at least 60 per cent of the crop had been destroyed by the maggots the previous year. In the Rush grove it was estimated that the condition was 75 per cent better than the year before when no treatment was given. No Persian walnut trees were found near either the Baile or Rush groves that were suitable for use in checking up definite results of the spraying. However, a comparison of the sprayed nuts with those produced by the same trees the previous season and with those produced in other localities the same season, together with the known abundance of the flies that appeared early upon the sprayed trees, indicates decidedly beneficial results from the treatment.

Flies confined in roomy wire-screen cages were observed to feed freely on sweetened water to which sufficient lead arsenate had been added to give the liquid a milky color. It must be admitted that these flies succumbed very slowly to the poison. Further tests of this treatment must be made before it can be recommended unreservedly as an effective and sure method of control for this pest.

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